ECOLOGICAL SUBSECTIONS OF GLACIER BAY NATIONAL PARK & PRESERVE, SITKA NATIONAL HISTORIC PARK, KLONDIKE GOLD RUSH NATIONAL HISTORIC PARK

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Glacier Bay National Park & Preserve
Klondike Gold Rush National Historic Park
Sitka National Historic Park

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Excerpts from
Ecological Subsections of Southeast Alaska and Neighboring Areas of Canada

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Ecological Subsection Delineation Criteria and Mapping

Along the rain-soaked West Coast, most ecosystem patterns and processes are ultimately traced to the land's ability to shed and process water. Given the importance of hydrologic processes, we chose physiography, lithology, and surficial geology as the principal delineation criteria for defining subsections. The use of these delineators has precedence in temperate rain forest systems. Montgomery (1997) found topo-geologic factors as important determinants of coarse-scale ecological patterns and processes and proposed their use for defining West Coast ecosystems. These physical factors embody the complex interplay of tectonic, geomorphologic, and hydrologic processes which, in turn, govern the distribution of habitat types and natural disturbances in these landscapes (Montgomery 1997). These factors explain much of the coarse-scale variation we see in vegetation (composition, structure, and productivity), soils (genesis, morphology, carbon and nutrient cycling), hydrology (stream channel types, groundwater levels, sedimentation rates, nutrient levels, lake and wetland distribution), fish and wildlife habitat and productivity, glacial history and erosional processes (landform features, surficial deposits), and natural disturbance regimes (type, frequency, intensity).

The region's physiography represents a topographically complex terrain exposed to repeated glacial activity. Broad physiographic areas were delineated, including icefields, recently deglaciated areas, large mainland river systems, angular mountains, rounded mountains, hills, lowlands, and recent volcanic fields. These distinct physiographies reflect the geomorphic and glacial history of the land—how continental icesheets flowed, scoured, and deposited materials over the land, superimposed on changes wrought by tectonics and volcanism.

Lithology and surficial deposits have profound effects on terrestrial and aquatic patterns and productivity in Southeast Alaska. Appreciable differences in water chemistry are associated with the type of bedrock from which they originate or contact (Wissmar et al. 1997). Substrate influences soil productivity to a lesser degree, with basalt and limestone having the most pronounced effects on soil chemistry (Heilman and Gass 1974). Seven generalized lithologies were delineated, including granitics, noncarbonate sedimentary, carbonate sedimentary, metasedimentary, complex sedimentary and volcanics, volcanics, and mafics/ultramafics. United States Geological Survey and U.S. Forest Service geologic maps were the sources of bedrock information (see Appendix A). We deferred to the 1:600,000 scale geology map of Gehrels and Berg (1992) where finer-scale information was not available. Many lithologic bodies (plutons, ultramafic intrusions) too small to distinguish at the subsection scale were grouped into larger adjacent rock bodies. Where surficial deposits of unconsolidated sediments effectively masked the underlying bedrock within lowlands, the type of deposition was identified as glacial till (ice-contact deposits), glacial outwash (glaciofluvial deposits), or glacial marine sediments (glaciomarine deposits).

Applying these topo-geologic criteria, we delineated more than 160 polygons on 1:250,000 topographic maps. Collaborations with Dennis DeMarchi (British Columbia Ministry of

Environment, Lands, and Parks) and Scott Smith (Agriculture and Agri-Food Canada, Research Branch) allowed delineation of polygons that extend into Canada. Each polygon was given a unique label and digitized in the Geographic Information System (GIS). Next, polygons possessing similar ecological characteristics were merged to form subsections. This process was aided by cluster analysis, a statistical procedure that groups or "clusters" items together based on their ecological similarity. For our exercise, polygons were populated with environmental data from the following GIS layers (note: these data were available only for lands within Tongass National Forest boundaries):

1. land cover type (alder, cedar, hemlock, poplar, hemlock-spruce, spruce, brush, freshwater, landslides, muskegs, alpine, ice-snow, or rock);
2. soil wetness (hydric or nonhydric);
3. forest site index (0-40, 41-60, 61-80, or >80); and
4. stream process groups (alluvial fan, estuarine, flood plain, glacial outwash, high gradient-contained, lake, palustrine, moderate gradient-contained, moderate gradient-mixed control, or low gradient-contained).

These data layers were selected because of their GIS coverage (spanning the entire 17-million-acre Tongass National Forest) and relative independence from the delineation criteria. These environmental data were converted to percentages and subjected to cluster analysis (unweighted pair-grouping method). Using the analysis results and our group's collective knowledge of climate, geomorphology, glacial history, soils, hydrology, and vegetation, we defined 85 subsections for Southeast Alaska and adjoining parts of Canada. Subsection names are concatenations of prominent local geographic features and the primary lithology (or the most ecologically significant bedrock type as in the case for carbonates) or surficial deposits occurring within each.

Hierarchical Arrangement and Final Correction

A hierarchical classification for subsections was created to reflect developmental histories of terrestrial surfaces of Southeast Alaska (Table 2). Three terrain classes were distinguished at the first level. Subsections currently affected by glacial processes (ice accumulation and movement, meltwater streams with heavy bedloads, deglaciated areas of primary succession) were classified as active glacial terrains. Older surfaces developing after the retreat of continental ice (≥14,000 years ago) fell into the inactive glacial terrain class. The majority of subsections occurred in this category. Subsections resulting from post-glacial processes not related to glaciation (i.e., volcanism) were classified as post-glacial terrains. These three classes were then divided by physiography. This second level was further subdivided by lithology and surficial geology (referred to as geologic classes) to form a third hierarchical tier.

Table 2. A hierarchical arrangement of subsections of Southeast Alaska and adjoining portions of Canada based on geomorphic and glacial origin, topography, lithology, and surficial deposits. The first, second, and third levels represent terrain classes (Roman numerals), physiographic classes (capital letters), and geologic classes (numbers), respectively.

I. Active Glacial Terrains
- A. Icefields
- B. Recently Deglaciated Areas
  - 1. Exposed Bedrock
  - 2. Unconsolidated Sediments
- C. Mainland Rivers
  - 1. Valleys
  - 2. Deltas

II. Inactive Glacial Terrains
- A. Angular Mountains
  - 1. Granitics
  - 2. Sedimentary, Noncarbonates
  - 3. Sedimentary, Carbonates
  - 4. Metasedimentary
  - 5. Complex Sedimentary & Volcanics
  - 6. Mafics/Ultramafics
- B. Rounded Mountains
  - 1. Granitics
  - 2. Sedimentary, Carbonates
  - 3. Metasedimentary
  - 4. Complex Sedimentary & Volcanics
  - 5. Volcanics
- C. Hills
  - 1. Granitics
  - 2. Sedimentary, Noncarbonates
  - 3. Complex Sedimentary & Volcanics
  - 4. Volcanics
- D. Lowlands
  - 1. Till Lowlands
  - 2. Outwash Plains
  - 3. Glaciomarine Terraces
  - 4. Wave-cut Terraces

III. Post-glacial Terrains
- A. Volcanic

Ecological Subsections of Glacier Bay National Park and Preserve

Icefields

Saint Elias—Fairweather

The Grand Pacific Glacier (lower right) is one of numerous large glaciers that originate in the St. Elias-Fairweather Icefields. Basal melting of temperate glaciers speed their travel. Glaciers act as conveyer belts, eroding and moving sediments as they flow. Note the development of linear medial deposits on top of the glacier through the accumulation and transport of debris scraped from the surrounding mountainsides.

Arcing terranes of Pacific origin have been thrust onto the North American continent forming a rugged ice-clad mountain chain adjacent to the Gulf of Alaska. The clashing of Pacific and North American plates has uplifted these

mountains to incredible heights—up to 19,000 feet! These towering mountains of faulted and folded sedimentary rocks intercept an abundance of maritime moisture, mainly in the form of snow, resulting in huge icefields, snowfields, and glaciers. Except for occasional nunataks and rock cliffs, ice and snow form a continuous sheet over these mountains. Seaward, many glaciers flow onto coastal flats where they form expansive lobes. Glacial streams carry bedloads of cobbles, sand, and silt during their rapid descent. These towering mountains, together with their massive icefields, form an effective barrier to Interior species movements, except along the Alsek River corridor. Thin and rocky soils exist where mountain summits and slopes are devoid of ice, snow, and active scree. Here, alpine communities of sedges, grasses, forbs, and low shrubs are home to mountain goat, brown and black bear, wolf, wolverine, hoary marmot, tundra vole, and ptarmigan. Alder and willow brushfields occur on rocky colluvial toeslopes and alluvial valley bottoms.

Land-Human Interactions. These rugged ice-mantled mountains have seen limited human use. During warmer interglacial periods (e.g., Hypsithermal climatic optimum) a greater portion of ice-free land was probably available to humans and the animals they hunted. Warmer times may have exposed additional corridors to the Interior, facilitating Native travel and commerce. Although unoccupied in historic times, several landforms are prominent in Tlingit legends, or have been incorporated as lineage crests by Tlingit clans. Many routes were tried across these mountains by stampeders during the Klondike Gold Rush, such as up and over the Nunatak Glacier. Today, U.S and Canadian agencies manage most of this area for wilderness and recreation. This huge subsection (>12 million acres!) includes portions of the Chugach National Forest, Wrangell-Saint Elias National Park and Preserve, Kluane National Park (Yukon Territory), Tatshenshini-Alsek Park (British Columbia), Glacier Bay National Park and Preserve, and the Tongass National Forest.

Recently Deglaciated Areas

Yakutat—Lituya Forelands

A vast foreland hugs the Gulf of Alaska formed by the seaward deposition of sediments from the coastal mountains. Glaciers, such as the LaPerouse Glacier shown above, continue to provide meltwaters and sediments that nurture this grand coastal wetland. Sedimentation, longshore transport, and tectonic activity have resulted in raised beach ridges immediately along the coast.

This foreland spreads seaward from the slopes of the St. Elias and Fairweather Mountains, forming a vast coastal plain. This gently sloping area is a complex of unconsolidated glacial, alluvial, and marine deposits that have been uplifted by tectonics and isostatic rebound. Parabolic dunes, formed from outwash sands, are scattered along the coast. Most are inactive and covered by forests or brushfields. The cool, maritime climate brings extended periods of overcast, fog, and precipitation. Winter snows are abundant and accumulate at sea level. Abundant precipitation and overland runoff from surrounding mountains keep the forelands perpetually wet. The surface sheds water slowly and is blanketed

with wetlands. Sitka spruce and hemlock forests occur sporadically where soil drainage permits along stream levees, moraines, and uplifted beach ridges. Sitka spruce and cottonwood are common on younger-aged surfaces, especially on recent outwash deposits near glacier margins. Glaciers fringing these flats emit cold waters laden with silt. These meltwater streams form a complex web of interconnected, braided channels as they spill over the flats. The high percentage of low-gradient, floodplain, and palustrine channels make these forelands unique among subsections. Groundwater-fed ditches, intertidal sloughs, and wetland ponds provide excellent salmon rearing habitat. Streams and large rivers, such as the Situk, Italio, Akwe, and Doame, support steelhead, Dolly Varden, and all five species of Pacific salmon. Spawning salmon deliver large amounts of nutrients to aquatic and terrestrial systems. Large mammals including brown and black bear, moose, and wolf are common land dwellers, whereas beaver, muskrat, and river otter inhabit the many rivers and streams.

Land-Human Interactions. This area is the homeland of the Gunaxoo Kwaan (north from Dry Bay) and the Yakutat Kwaan (Yakutat Bay south), and is rich in archaeological sites and Tlingit legends. Local Tlingits were less seagoing then their southern kinsmen because of the abundant food resources of the forelands and its rivers (Goldschmidt and Haas 1998). Many of the earliest interactions between explorers and local Natives took place along this stretch of coast, so it is also rich in history. Today, the southern third of this subsection is within Glacier Bay National Park and Preserve, whereas the northern two-thirds is within the Tongass National Forest. The Yak-Tat Kwann, Inc. and the State of Alaska manage large land holdings around the community of Yakutat. The majority of the National Forest System lands are managed for natural settings and wilderness, with a limited amount available for development. Extensive timber harvest has occurred on both National Forest System and Native lands. The area from Yakutat to Dry Bay is particularly important for commercial fisheries and subsistence activities. The Situk River is one of the most important salmon streams in Southeast Alaska.

Upper West Arm Mountains

The recent liberation of this mountainous fjordland from ice is vividly displayed along the east shore on Tarr Inlet. Steep, rocky mountainsides plunge to the sea largely devoid of vegetation, being swept regularly by winter avalanches and washed by summer rains. Rock debris and sediments have been transferred to the mouths of deeply incised valleys, forming deltaic fans. At lower elevations, early successional plants have a spotty distribution occurring where skeletal soils have developed on more stable surfaces.

These steep-walled, rugged mountains surround Glacier Bay at its northern limit, making for impressive scenery. Here, neoglacial ice retreated slowly during the past hundred years. Glacial activity has been erratic, occurring in a series of retreats and surges. Today, an assemblage of tidewater glaciers still exists, including the Reid, Johns Hopkins, Lamplugh, Margerie, and Grand Pacific Glaciers. These creep down mountain notches or along large fault zones, filling fjords with icebergs. Marine mammals, particularly seals, are common in these iceberg-laden waters. Moderately high levels of precipitation keep the granodiorite and metasedimentary masses relatively clean of sediments through rainwash in the summer and avalanching in the winter. Glacial deposits are

sparse. Some sediment has accumulated along the shorelines and in small depressions. The mountains are largely devoid of soil and plant life except along shorelines. The open habitats of ice, rock barrens, and low-growing plants support limited use by brown and black bear, mountain goat, wolf, wolverine, hoary marmot, and tundra vole.

Land-Human Interactions. Native Tlingits made use of this area and surrounding waters during interglacial "ice-free" times. Historic Native use of this land was probably limited by its recent liberation from ice. Presently, the area is designated wilderness within the Glacier Bay National Park and Preserve. This steep-sided fjordland of calving tidewater glaciers is the primary destination of tour boats operating in the park.

Hugh Miller-Geikie Inlet Mountains

The Hugh Miller Glacier (back center) represents one of many glaciers that pour into the Hugh Miller-Geikie Inlet Mountains from the west. Here, glacial meltwaters flow across outwash deposits into Weird Bay, then Scidmore Bay (foreground).

Neoglacial ice has repeatedly scoured the west side of Glacier Bay exposing a mix of granitic, metasedimentary, and metavolcanic rocks. Here, fairly deep deposits of unconsolidated sediments surround the rounded mountains. Sediments continue to flush into its major valleys from meltwaters of retreating glaciers to the west. Several large fjords penetrate these mountains as they descend eastward into Glacier Bay. Because glaciers from the most recent advance encased this area in ice until the early 1900s, this youthful surface exhibits soil formation and vegetation colonization in the most primary stages. Exposed bedrock outcrops, devoid of vegetation, dominate the mountain scenery. Streams fed by moderately high precipitation routinely flush these mountains of sediment, making it difficult for plants to become established on upper elevations. Forbs, grasses, and shrubs fringe mountain toeslopes and extend across broad valleys and lowlands. Cottonwood and, increasingly, spruce trees are appearing along shorelines and in valleys. Common mammal species

include brown and black bear, mountain goat, moose, wolf, wolverine, hoary marmot, and tundra vole.

Land-Human Interactions. Native Tlingits made periodic use of this area and surrounding waters during interglacial "ice-free" times. The duration of Native use of this land is probably short given its recent liberation from ice. Presently, the area is designated wilderness within the Glacier Bay National Park and Preserve. Wilderness extends into the waters of Hugh Miller Inlet, Scidmore Bay, and Charpentier Inlet, representing one of the few places in Southeast Alaska where marine waters have this special designation.

Dundas River Flats

The Dundas River meanders southeastward across broad wetland flats before emptying into Dundas Bay (far right center). These outwash flats formed when neoglacial floodwaters spilled down mountain valleys, filling them with coarse-textured sediments. The mouth of Glacier Bay lies behind the cloud-covered White Cap Mountain, which is part of the adjacent Berg Bay Complex.

Glacial floods culminating about 250 years ago produced this intricate outwash plain. Apparently, neoglacial ice retreating from Geikie Inlet and Berg Bay shed huge volumes of meltwater into the Dundas River system (Streveler and Paige 1971). These sediment-laden meltwaters filled low-lying valleys with gravels and sands, providing coarse sediments that now support sparse forests of cottonwood, Sitka spruce, and lodgepole pine amongst Sitka alder and willow wetlands. The mineral soils are inherently wet due to low topography, moderately high precipitation, and a high water table. Moose, brown and black bear, marten, and red squirrel are common inhabitants.

Land-Human Interactions. Unglaciated during the neoglacial, this land provided a refuge for humans. Archaeological evidence indicates fairly continuous

occupation during the past 800 years. Tlingit legend identifies much of the southern portion of this area as being part of Dundas Bay at the time of occupation. For example, the village of L'istee was said to be located where the Dundas River flows into the bay, but today the archaeological remains of L'istee lie several miles up the Dundas River from the bay. A second site, Xunakawoo Noowu', described as being on an island at the mouth of the river, now lies a mile above the mouth of the river. The brushy habitats resulting from the last neoglacial flood provided Natives with ample berry picking and hunting opportunities. Today, the area occurs within the wilderness portion of the Glacier Bay National Park and Preserve.

Berg-Beardslee Moraine

Looking north from Point Gustavus, rolling moraines line the eastern shores of Glacier Bay and underlie the Beardslee Islands (upper center). These well-drained, heavily forested moraines contrast sharply with the open, scrubby wetland complexes of the Gustavus Flats on the right.

During the "Little Ice Age" ice overflowed lower Glacier Bay and spilled onto adjacent lands. Here, retreating and advancing neoglacial ice created a series of terminal and lateral moraines. The rolling surface is comprised of well-drained mineral soils of till origin. Close proximity of refugial seed sources caused trees to quickly occupy these soils after deglaciation (Fastie 1995). The area is now densely forested with first generation stands of Sitka spruce and some western hemlock. Mature cottonwood and alder forests that have developed on high terraces since deglaciation (early 1800s) are now sources of large woody debris for streams (Sidle and Milner 1990). By accumulating in-stream and against banks, these fallen materials stabilize channels by absorbing stream energy, armoring banks, and storing sediments. Forest inhabitants include moose, brown and black bear, marten, red squirrel, and the occasional Sitka black-tailed deer.

Land-Human Interactions. Natives have long used this general area and surrounding waters during interglacial "ice-free" times. Hoonah Tlingits occupied this area immediately after ice retreat, subsisting on the rich marine (fish, seals, and birds) and terrestrial (wild berries and vegetables) life. This area is likely the Tlingit homeland described in the Glacier Bay legend. Berg Bay is the origin of the Chookeneidi clan of the Hoonah Tlingit; Bartlett Cove and Point Gustavus also supported important clan houses. A number of Tlingit legends originate from this area. Today, the area is within the Glacier Bay National Park and Preserve. Most of the area is designated wilderness except for a small portion around Park Headquarters. The marine waters around the Beardslee Islands are also designated wilderness, a unique status in Southeast Alaska.

Gustavus Flats

A large outwash plain formed by neoglacial floodwaters lines the north shore of Icy Strait (upper right). The foreground lobes of dense forests are part of the Berg-Beardslee Moraine where neoglacial ice stagnated and floodwaters emerged on its retreat. The Gustavus airport and community are located across the top of the photo.

Glacial floods culminating about 250 years ago produced this intricate outwash plain. Apparently, neoglacial ice retreating from Geikie Inlet and Berg Bay shed huge volumes of meltwater into the Dundas River system (Streveler and Paige 1971). These sediment-laden meltwaters filled low-lying valleys with gravels and sands, providing coarse sediments that now support sparse forests of cottonwood, Sitka spruce, and lodgepole pine amongst Sitka alder and willow wetlands. The mineral soils are inherently wet due to low topography, moderately high precipitation, and a high water table. Moose, brown and black bear, marten, and red squirrel are common inhabitants.

Land-Human Interactions. Unglaciated during the neoglacial, this land provided a refuge for humans. Archaeological evidence indicates fairly continuous occupation during the past 800 years. Tlingit legend identifies much of the

southern portion of this area as being part of Dundas Bay at the time of occupation. For example, the village of L'istee was said to be located where the Dundas River flows into the bay, but today the archaeological remains of L'istee lie several miles up the Dundas River from the bay. A second site, Xunakawoo Noowu', described as being on an island at the mouth of the river, now lies a mile above the mouth of the river. The brushy habitats resulting from the last neoglacial flood provided Natives with ample berry picking and hunting opportunities. Today, the area occurs within the wilderness portion of the Glacier Bay National Park and Preserve.

Wachusett-Adams Hills

The recently deglaciated surface of the Wachusett-Adams Hills looking northeast across Casement Glacier outwash. The north shore of Adams Inlet appears at the upper right. Vegetation succession began after neoglacial ice retreat, starting in the early 1900s. Past glaciers have effectively eroded the mountains into rolling hills adjacent to the Adams Inlet basin.

Thick layers of early- to mid-Holocene glacial outwash, lacustrine materials, and other glacial sediments cover this rolling terrain. This lowland basin, centered on upper Muir Inlet, contains fingers of low rolling hills that radiate from the surrounding mountains. The glacial history of this area is convoluted, with repeated neoglacial flows affecting individual inlets with each advance and retreat. For example, the Adams Inlet area has a wide range of deposits, including ice-contact tills, lacustrine sediments, glaciofluvial outwash, and glaciomarine deposits, all representing ice-water-land interactions (McKenzie and Goldthwait 1971). Thick lacustrine deposits are most notable, originating when neoglacial ice dammed the inlet and formed Glacial Lake Adams. During the last neoglacial period, ice filled Adams Inlet, cresting at 2,500 ft. about 250 yrs. ago (Reid 1892; McKenzie and Goodwin 1987). About 100 years ago ice was 1,300 ft thick. During ice retreat, sediments from glacial meltwaters and mountain runoff were deposited along the margin of Adams Inlet Glacier. These ice-marginal

deposits formed mountainside terraces that are in various stages of slumping or eroding onto the valley floor. Melting ice buried in these deposits has led to collapsed topography that continues today (McKenzie 1969; McKenzie and Goodwin 1987).

The unifying theme of this subsection is its youthfulness. Indeed, the area has been slow to escape the grip of neoglacial ice—a process starting in the 1860s and continuing today! Geographic remoteness and isolation has retarded primary plant succession and restricted it to pioneer species possessing light, wind-dispersed seeds. This scenario is different in several key respects from similar deglaciated surfaces in lower and western Glacier Bay (see Fastie 1995). Alder (a nitrogen-fixing plant) and cottonwood dominate the southern half of this subsection and are restricted to shorelines and valley bottoms in the northern half. Vegetation development plays a key role in stream morphology (Sidle and Milner 1990). In the barren upper portions of Muir Inlet, dynamic meltwater streams with very high sediment loads and braided channels have emerged from recent ice retreat. In lower Muir Inlet, sufficient time has elapsed since deglaciation (late 1800s) for streams to stabilize through vegetative means (e.g., by roots and woody debris trapping sediments and providing bank stability). Moose, brown and black bear, and mountain goat are common in these hills and flats. Moose arrived in the 1960s presumably through the Endicott Pass (Dinneford 1990).

Land-Human Interactions. Tlingits used this area during interglacial "ice-free" periods. The history of Native use is probably short given its recent liberation from ice. Today, the entire area is wilderness in Glacier Bay National Park and Preserve. Wilderness protection extends across the waters of Adams Inlet—a rare designation for Southeast Alaska marine waters.

Queen-Tidal Inlet Mountains

Steep, glacially scoured mountains abut Russell Passage (lower left) and Rendu Inlet (far right) within the upper reaches of Glacier Bay. Here, alpine snowfields, barrens, and meadows cover much of the mountainous landscape. Forests and brushfields are restricted to lower elevations, mostly fringing the coastline.

Rugged angular mountains frame the northeast side of Glacier Bay's West Arm from Russell Island through Tidal Inlet. A mix of noncarbonate and carbonate sedimentary and metasedimentary rocks with granite inclusions is exposed throughout this stark landscape. This area was encased in neoglacial ice until the mid-1800s. It took 30 years of rapid glacial retreat (1860-1890) to fully reveal this landmass. Where previously covered in ice, the surface possesses youthful characteristics. Glacial drift was deposited in valleys and along mountain slopes. Moderately high precipitation feeds swift and clear mountain streams. Winter avalanches routinely sweep the slopes. The slopes of these mountains are lushly vegetated and heavily used by brown and black bear. Elevations above 2,400 feet escaped the last resurgence of neoglacial ice and have lush, mature alpine communities well populated by mountain goat. Other common animals include moose, wolf, wolverine, hoary marmot, and tundra vole.

Land-Human Interactions. Native Tlingits made brief use of this area and surrounding waters during interglacial "ice-free" times. Historic Native use was probably limited due by the area's recent liberation from ice. Presently, the area is designated wilderness within the Glacier Bay National Park and Preserve. Wilderness waters exist within Rendu Inlet, representing one of the few places in Southeast Alaska where marine waters have this status. Tour boats routinely ply the non-Wilderness waters along this scenic subsection.

Mainland Rivers

Alsek-Tatshenshini River Valleys

The waters of the Alsek form braided channels that meander through a broad valley floodplain. Note the glacial and alluvial materials spilling onto the floodplain from notches along the steep sideslopes. This photo looks eastward towards Canada where the Alsek cuts through the Saint Elias Range, one of the few mainland rivers to do so.

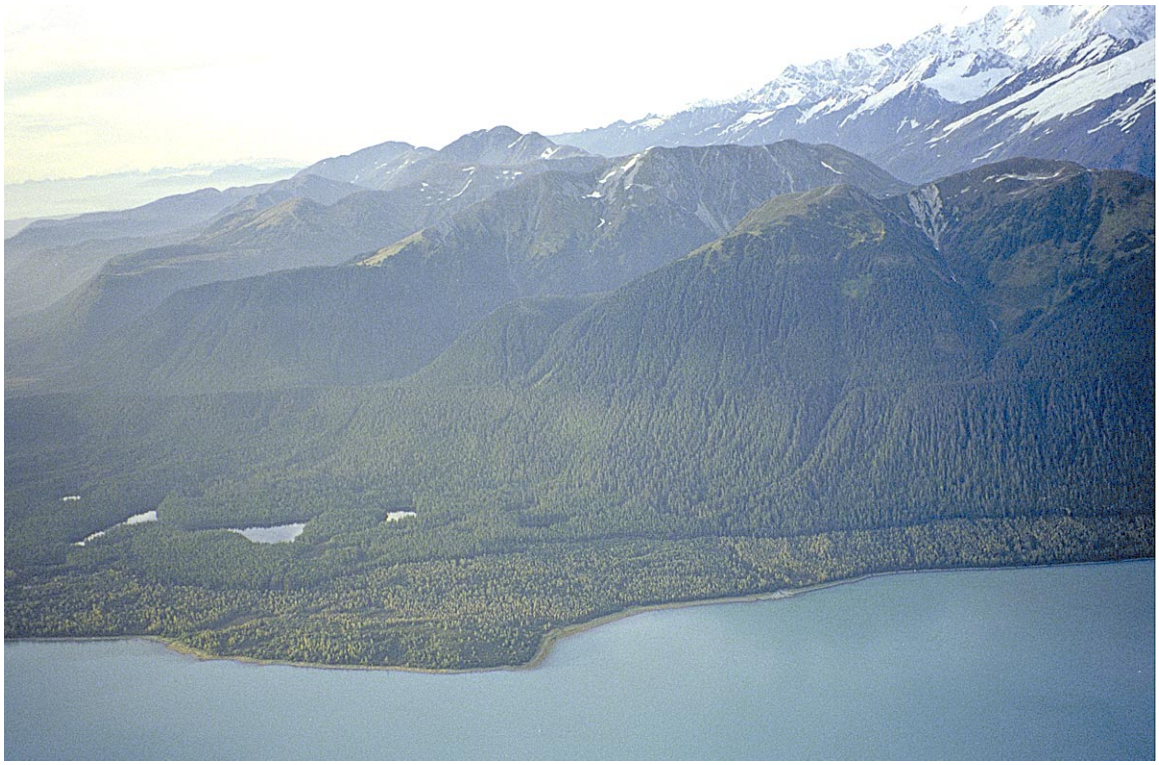
This is one of the few river systems originating in the Canadian Interior that passes through the St. Elias Range. It probably predates the interposition of the coastal mountains between the Yukon Plateau and the sea (Lindsey and McPhail 1986). The combined watershed of these rivers was much more extensive during the Miocene, draining most of southern Yukon Territory (Conner and O'Haire 1988). However, repeated glaciations impeded flow through the coastal mountains, allowing the Yukon River to pirate much of the headwaters. A huge headwater lake, called Glacial Lake Champagne, formed during the last ice retreat and eventually drained down the Alsek River (Lindsey and McPhail 1986). Today, meltwater streams flowing from the Alsek Ranges serve as the primary water source of the Alsek and Tatshenshini Rivers. These rivers join prior to entering the United States. Braided channels running through broad, flat-

bottomed valleys characterize much of their length. Many alluvial terraces and coalescing fans emanating from side valleys are also present. The Lowell Glacier in the Yukon Territory has dammed the Alsek River at least four times in the last 500 years (Clague and Rampton 1982). The resulting huge glacial outburst floods (jökulhlaups) formed many of the large terraces along the river corridor. The last flood occurred less than 150 years ago (Clague and Rampton 1982). High flows in July have exceeded 100,000 cubic feet/second when glacial runoff is at its peak. The mineral soils in this corridor are very young. Much of the drainage occurs on the Interior (rainshadow) side of the coastal mountains where a drier continental climate prevails. Boreal plant communities predominate along much of its length, although riparian forests at its lower end contain a mixture of white spruce and quaking aspen from the continental interior and black cottonwood from the maritime coast. Moose, brown and black bear, wolf, river otter, mink, beaver, lynx and snowshoe hare populate the riparian habitats.

Land-Human Interactions. This river corridor has long been one of the main trading routes between coastal Tlingit communities and the Indian groups of the Interior. The valleys play prominently in Tlingit clan legends and in the story of creation. In Tlingit creation mythology, Raven traversed these river valleys as he created the world, and many landforms along the river corridor are associated with Raven's activities at that time. In the last 20 years both the Alsek and Tatshenshini Rivers have become very popular river rafting destinations. The upper portion of this river corridor lies within the Tatshenshini-Alsek Park of British Columbia, whereas the lower portion occurs within the Glacier Bay National Park and Preserve wilderness.

Angular Mountains

Fairweather Front Range Complex



A set of coastal mountains north of Lituya Bay (front) separates coastal forelands (lower left) from the towering Fairweather Range (upper right). A deep ice-filled trench, called Desolation Valley, lies behind the Front Range, separating it from the St. Elias-Fairweather Icefields.

This narrow mountain strip faces the Gulf of Alaska and is sandwiched between the Fairweather Range and the Yakutat-Lituya Forelands. The ice-filled Desolation Valley along the Fairweather fault separates it from the Fairweather Range. These fragmented mountains are breached in multiple locations by ice flowing from Desolation Valley onto the coastal forelands. This area, where the Pacific and North America plates make contact, is one of the most tectonically active areas of the world. Mildly metamorphosed volcanic greywacke and greenstone and associated rock types comprise the majority of these mountains. Some marine siltstones and sandstone from the Yakutaga formation have been uplifted thousands of feet in a relatively short time. The 1958 earthquake, which precipitated an enormous landslide and tsunami in Lituya Bay, was centered in this area. Even today, when flying over this area, the evidence of this tsunami is still easily seen. The ocean-facing western slopes are temperate and partially

forested, whereas the eastern slopes near glaciers are cold and nonforested. The Front Range is home to mountain goat, brown and black bear, wolf, wolverine, hoary marmot, tundra vole, meadow jumping mouse, and ptarmigan.

Land-Human Interactions. The Hoonah Tlingits, a coastal people, probably made minimal use of these remote mountains. Although unoccupied by humans, several Front Range peaks play prominently in Tlingit legends, and several landforms have been incorporated into Tlingit clan crests. Today, the area is located within the Glacier Bay National Park and Preserve, most of which is designated wilderness.

Cape Spencer Complex

An even-spaced series of ridges and fjords line the Pacific Ocean just north of Cape Spencer. This repeating sequence is captured from Astrolabe Peninsula looking southeast across Dixon Harbor, Hankinson Peninsula, and beyond. Sugarloaf Island is at center right. Severe weather conditions rack this exposed area, helping restrict tree growth to shorelines and lower mountain slopes.

This highly dissected fjordland represents the southern extent of the Fairweather Range as it descends into Cross Sound. It is a rugged, ice-free terrain of moderately to highly metamorphosed rocks such as gneiss and schist. A small mafic/ultramafic body is intruded near Palma Bay. The close proximity of the Brady Glacier has profoundly influenced this area. At various times in the past, when the Brady Glacier extended out farther, outwash fans and ice-dammed lakes formed along its flanks. The interactions between the Brady Glacier and these steep coastal mountains have resulted in a fascinating array of glacial deposits in the valley bottoms. Additionally, there are a number of raised marine terraces along the outer coast. The outer mountain slopes are forested with hemlock, spruce, and yellow cedar. The younger outwash fans support mixed cottonwood-spruce forests. Forested and nonforested wetlands dominate the raised marine terraces along the coast. The diverse landscape provides habitat

for mountain goat, brown and black bear, moose, wolf, wolverine, hoary marmot, and tundra vole.

Land-Human Interactions. Hoonah Tlingits used this area for hunting and fishing prior to European arrival. This is the homeland of the T'akdeintaan clan of the Hoonah Tlingit, where several villages existed prior to the arrival of Europeans. Tlingit legends also make reference to this area before contact. Today, the area is in the wilderness portion of Glacier Bay National Park and Preserve. Beneath the Brady Icefield within the adjacent St. Elias-Fairweather Icefields is a 400-acre mining claim containing a substantial ore deposit. If technical engineering challenges can be overcome, development of this claim could result in construction of a large mining and milling operation at Dixon Harbor in the middle of the Cape Spencer Complex.

Chilkat Peninsula Carbonates

The angular profile of the Chilkat Range as it appears from the eastern shores of Glacier Bay. This rugged range forms the spine of the Chilkat Peninsula, harboring many icefields, glaciers, and permanent snowfields. Snow avalanches commonly sweep upper mountain slopes. Forests fringe shorelines and occupy larger valley bottoms.

The rugged, snow-clad Chilkat Range branches south from the St. Elias Mountains to form a picturesque peninsula separating Lynn Canal and Glacier Bay. This towering range sports a dense network of incised rivers and streams that emanate from small glaciers and snowfields. These swift glacial streams carry heavy bedloads that form deltaic fans as they discharge along mountain bases. The lithology is comprised of a matrix of sedimentary rocks (sandstones) with numerous bands of carbonates. Because of its sheer height, alpine snowfields, barrens, and meadows cover much of the area. Small glaciers and icefields dot the highest mountains. Some epikarst is present as well. At mid-elevation, alpine habitats are replaced by subalpine shrublands and stunted "krummholz" forests. Hemlock and hemlock-spruce forests cover lower mountain slopes, valleys, and coastal areas. Inherent instability and snow loading cause landslides, debris flows, and avalanches in steep terrain. Infrequent wetlands are restricted primarily to coastal lowlands. The Endicott River cuts through this range at its northern end, and may have provided the corridor through which moose entered Glacier Bay in the 1960s (Dinneford 1990). Common mammals

include brown and black bear, mountain goat, moose, wolf, wolverine, marten, and hoary marmot.

Land-Human Interactions. The Chilkoot and Auk Tlingits inhabited the east side of the Chilkat Peninsula, whereas the Hoonah Tlingits used its western side. One of the oldest archaeological sites in Southeast Alaska at Groundhog Bay indicates that a maritime culture inhabited the region 10,000 years ago (Ackerman 1968). The steepness and ruggedness prevented the Natives from traveling far inland and restricted their activities to shoreline hunting, fishing, and shellfish digging. Logging on the peninsula began in the early 1900s, providing lumber for a large cannery at Excursion Inlet and a copper mine works at William Henry Bay (Roppel 1991). Recent timber harvests concentrated on the southern tip of the peninsula affect about 6 percent of the productive forest lands. Most of the area is managed for natural settings and wilderness. The Endicott River Wilderness and Glacier Bay National Park and Preserve encompass the northern end of this subsection, and the St. James Bay State Marine Park occurs along Lynn Canal on the eastern side.

Dundas Bay Granitics

The waters of Dundas Bay infuse a rugged set of granite-based mountains east of the Brady Glacier. These mountains, rising to 3,000 feet, are capped with alpine barrens and meadows and fringed by conifer forests. The steep slopes are dissected by avalanche and landslide chutes.

Highly dissected mountains curl around the upper branches of Dundas Bay. These fragmented mountains consist of granite and metamorphosed sediments and volcanics, particularly amphibolite and gneiss. A large complex moraine system forms a narrow strip of land (isthmus) between Taylor Bay and Dundas Bay bounded by bedrock on both sides. This rugged terrain was not overridden by neoglacial ice to any appreciable extent. The mountain slopes are covered with forests of hemlock, spruce, and yellow cedar. These forests become stunted and fragmented as they reach subalpine meadows and avalanche brush fields at about 1,500 feet. Mountain goat, black and brown bear, moose, wolf, wolverine, hoary marmot, and tundra vole inhabit this mountainous terrain.

Land-Human Interactions. The unglaciated portions of this landscape provided refuge for humans during neoglacial periods. Hoonah Tlingits used the marine waters and uplands of this subsection prior to European arrival. Today, the entire area is designated wilderness within the Glacier Bay National Park and Preserve.

Wilderness extends into the upper arms of Dundas Bay—a unique designation for Southeast Alaska marine waters.

Rounded Mountains

Berg Bay Complex

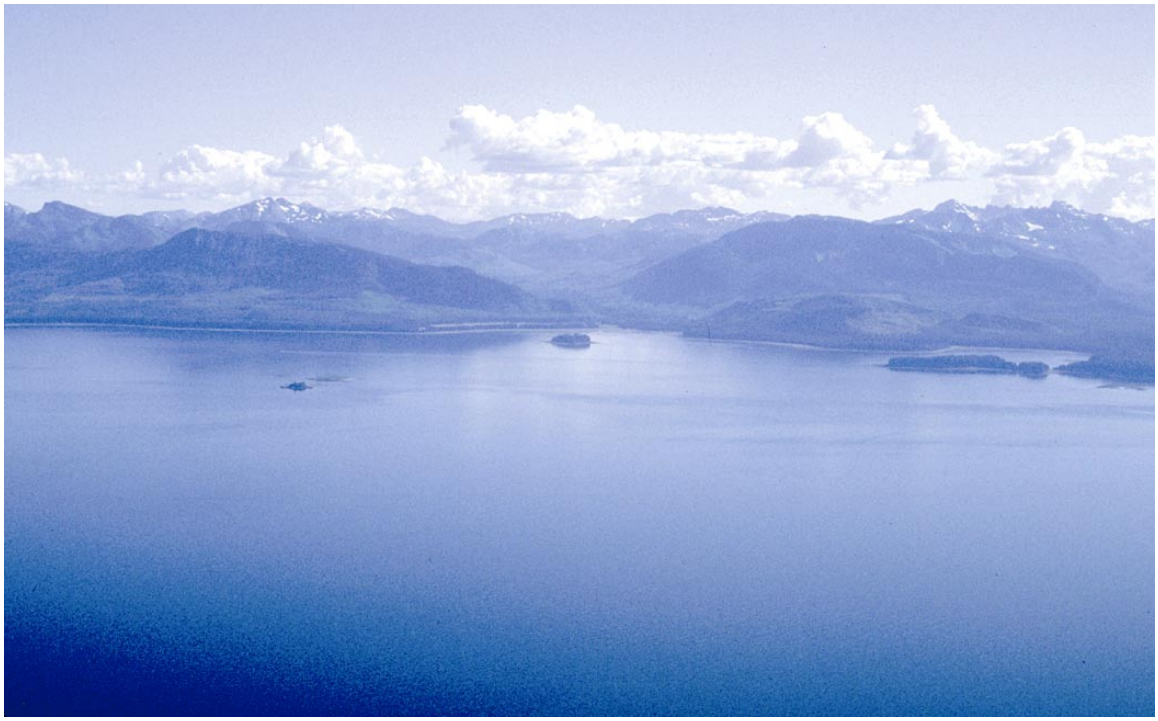
A mountain V-notch within the Berg Bay Complex frames Fingers Bay and Whidbey Passage on the west side of Glacier Bay looking northward. Mountain forests give way to avalanche openings and alpine communities at about 1000 feet above sea level. The pale-colored mountain in the back center is Marble Mountain, which partially obstructs Drake Island.

This subsection encompasses a series of fragmented mountains spanning the western side of lower Glacier Bay and Lemesurier Island in Icy Strait. This subsection contains mixed lithologies of noncalcareous sediments and granitic bedrock. Some carbonates exist within Marble and White Cap Mountains. Neoglacial ice was 1,900 feet thick at Marble Mountain, but attenuated quickly off to the sides as it reached its Little Ice Age maximum. Lobes extended only into the fringes of the Dundas Valley out of Berg Bay, Fingers Bay, and Geikie Inlet. None of the mountaintops were covered. Wetlands not covered by neoglacial ice are generally mature bogs and fens in the intermontane swales. Common land animals include brown and black bear, mountain goat, moose,

wolf, wolverine, hoary marmot, tundra and long-tailed vole, river otter, and mink.

Land-Human Interactions. The Chookaneidí clan of the Hoonah people occupied much of this subsection within Glacier Bay. The T'akdeintaan clan of the Hoonah Tlingits once occupied forts on Drake and Lemesurier Islands. The waters surrounding Lemesurier Island were highly valued for seal hunting. Today, the entire mainland area is designated wilderness within the Glacier Bay National Park and Preserve. Lemesurier Island is part of the Pleasant-Lemesurier-Inian Island Wilderness managed by the U.S. Forest Service.

Point Adolphus Carbonates



Relatively low-relief mountains surround Gallagher Creek drainage as viewed from the east. This subsection has the most subdued topography of the three carbonate subsections on eastern Chichagof Island. Forests blanket a good portion of these hills and rounded mountains.

This subsection occupies the northeastern corner of Chichagof Island bordered by Icy Strait and Port Frederick. The bedrock consists primarily of sedimentary rocks. An important component is composed of limestone and marble. There are also some volcanics such as andesite. The north side of this subsection, particularly, is actively uplifting following the recent retreat of glaciers from adjacent Glacier Bay (isostatic rebound) and local tectonism. As a result, young supratidal meadows and beachfront forests line much of its coastline. Neka Bay and Mud Bay are estuaries having extensive tidal meadows—rather rare features in Southeast Alaska. Most of the productive forests are composed of hemlock-spruce and hemlock. Wetlands are common, making up about 30 percent of this subsection, while lakes and ponds are relatively rare. Common mammals include brown bear, Sitka black-tailed deer, marten (introduced), ermine, red squirrel (introduced), common shrew, Keen's mouse, and long-tailed vole.

This is the northernmost of three carbonate-based subsections on eastern Chichagof Island. The Point Adolphus Carbonates is the most rolling and has

more hill landforms than the other two subsections. Freshwater bodies are much more infrequent here compared to the other carbonate subsections as well.

Land-Human Interactions. Hoonah Tlingits remain the principal users of this area. Neka Bay on Port Frederick has a long history of subsistence use, including berry picking, salmon fishing, and hunting (Goldschmidt and Hass 1998). There, large Native smokehouses processed pink, chum, and silver salmon. Today, the northern portion of this subsection is within a congressionally designated roadless area. Over a quarter of National Forest System lands are managed for intensive development, where about 2,400 acres have been harvested to date. Huna Totem and Sealaska Corporation own the eastern one-quarter of the subsection where thousands of acres have been harvested in the 1990s. Whales often congregate near Point Adolphus, making it a popular destination for wildlife viewing. Ecotourism has increased in this area by over 100 percent in the last 10 years.

Hills

Salmon River Sediments

A flowing mix of forested and nonforested wetlands spread across the Salmon River Sediments at the base of Excursion Ridge. A trellis-like drainage pattern has resulted from waters collecting within and breaching across glacial scours oriented in a northwest-southeast direction.

These calcareous argillite sedimentary foothills of the Chilkat Range gently slope southwest towards Glacier Bay. The area was heavily scoured by continental ice during the last great glacial period and retains conspicuous northwest-southeast trending, structurally controlled grooves on its surface. The soilscape and vegetation have developed since that time, unscathed by neoglacial ice readvances that have inundated neighboring areas. As such, this subsection is very distinctive compared to the younger surrounding landscapes. Although these foothills receive only moderate levels of precipitation, terraces within the area are poorly drained and capped with deep organics. Wetland complexes are abundant and include an intermixture of scrubby lodgepole pine forests and open ericaceous bogs and fens. Small streams meander across the wetlands and

become contained within glacially scoured valleys. Streams merge and eventually breach across the northwest-southeast trending topography, forming a trellis-like network as they descend onto the flats. Lush hemlock-spruce forests occupy steeper places. All forests are exceptionally brushy in the understory, probably due to the fertility of calcareous soils. Common land mammals include Sitka black-tailed deer, moose, brown and black bear, wolf, wolverine, marten, porcupine, Keen's mouse, and red squirrel.

Land-Human Interactions. The area falls within the territory of the Hoonah tribe. Because of the area's isolated location and wetland cover, Native use was probably slight except along the shoreline. This subsection is located in the Glacier Bay National Park and Preserve and is managed as wilderness.

Lowlands

Stephens Passage Glaciomarine Terraces

A view of Mansfield Peninsula looking northward up Lynn Canal. Barlow Island is on the right and Lincoln Island is in the distance. The relatively flat topography, low productive forests, and nonforested wetlands aptly characterize this subsection.

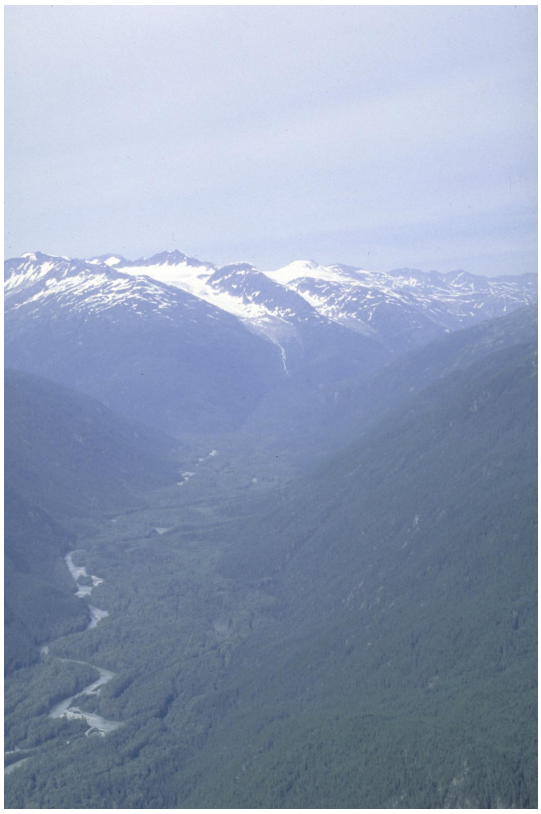
Massive continental glaciers descended through Lynn Canal, Icy Strait, Chatham Strait, and Stephens Passage, severely eroding adjacent surfaces along the way. After their retreat, marine flooding of low-lying areas covered surfaces with fine-textured glaciomarine sediments. This surficial deposit, known as the Gastineau Channel Formation, consists of a fine-grained matrix of silt and sand containing pebbles and occasional larger dropstones (Miller 1973). Tectonics and isostatic rebound have since raised these surfaces out of the sea, forming terraces that grade into scoured hills and mountain slopes. These glaciomarine terraces are rimmed by estuaries and salt marshes along the coast and are blanketed by alluvial and colluvial deposits along mountainsides. Bedrock hills and knobs often have elliptical shapes that parallel ice sheet movement from the north. Much of the area slopes northeast or southwest towards the major northwest-southeast trending waterways that dissect this subsection. Most surfaces have low

permeability because of their fine texture and gentle slope. Organic soils underlie these wet surfaces and support vast wetland complexes of mixed conifer and lodgepole pine forests interspersed with open, shrubby bogs. Scoured surfaces with thin glaciomarine and till deposits are often covered with organics and possess wetlands oriented in the direction of glacial scrape. More productive hemlock and hemlock-spruce forests occur on better-drained mountain slopes, hilltops, and along incised streams and beachfronts. Swift, high gradient streams incise mountain slopes. Upon reaching terraces, stream channels change to moderate gradient, floodplain, and palustrine types. Pleasant Island, a plateau-like volcanic knob laden with wetland forests and open bogs, forms the western extent of this subsection. Common land animals include brown bear, black bear (mainland only), Sitka black-tailed deer, marten, ermine, mink, beaver, river otter, muskrat, dusky shrew, red squirrel, Keen's mouse, and long-tailed vole.

Land-Human Interactions. This area was the homeland of the Auk Tlingit, who subsisted on salmon, halibut, game, shellfish, furbearers, garden vegetables, and berries. Native villages were located at Auk Bay, Barlow Cove, and Berners Bay. The mainland portion of this subsection lies within the mineral-rich Juneau Gold Belt. Major gold strikes in the late 1800s attracted many miners. Most accessible forests along beachfronts and lower slopes were logged to support the mining industry. Today, many of the better-drained areas support century-old stands of second growth. Active mining continues today, primarily on the mainland. Areas located within the city of Juneau are heavily developed and largely privately owned. Most of the National Forest System lands are managed for mostly natural settings, wilderness, and monument. The Mendenhall Wetlands State Game Refuge located along Gastineau Channel is an important rest stop for migratory ducks, geese, and shorebirds during the spring and fall.

Klondike Gold Rush National Historic Park

Chilkat Complex



The effects of glaciation are indelibly etched in this landscape, as represented by the Taiya River Valley northeast of Dyea. Following faults and bedrock weaknesses, continental ice sheets from the coastal mountains converged on and intensely scoured the Chilkat Complex. Today, forests cover valley bottoms and lower mountain slopes, whereas alpine barrens and meadows cap mountains. Avalanches commonly sweep upper mountain slopes.

This glacially scoured terrain is sandwiched between two towering mountain ranges along the U.S.–Canada border. A number of faults, including the great Denali fault, cut through this subsection and underlie deep, glacially carved valleys among rounded mountains. The orientation of these faults gives rise to parallel ridges and valleys that radiate like wheel spokes from the head of Lynn Canal. The unique geographic location of this subsection produces an unusual mix of maritime and Interior characteristics. The St. Elias, Fairweather, and Chilkat Ranges to the west greatly affect the weather, protecting the area from severe coastal storms and monsoon-like rains. The area receives about 100

inches of precipitation per year—a moderate sum by Southeast Alaska standards. Clear and dry weather systems regularly push in from the Interior, providing warm sunny weather during the summer and cold dry weather during the winter. The clash of cold continental and moist maritime air in winter fosters abundant snow cover that persists well into spring. The flora of the area also reflects maritime and Interior mixes. At low elevations, cottonwood occurs along rivers and streams and throughout floodplains. Outside riparian areas, hemlock and spruce forests dominate valley floors and colluvial toeslopes. Interior-like lodgepole pine and birch forests occur to mid-slope positions on shallow organic soils over talus or bedrock. These slopes are dissected by landslide and avalanche chutes. Scouler's willow and Sitka alder are abundant throughout. Alpine and subalpine communities of shrubs and forbs occur on thin organics on upper slopes and mountaintops. Alpine barrens often cap mountaintops. Common land mammals include brown and black bear, moose, mountain goat, wolf, wolverine, porcupine, hoary marmot, snowshoe hare, and northern red-backed, meadow, tundra, and long-tailed vole.

Land-Human Interactions. Humans have long used this area due to its desirable climate, abundant resources, and strategic location. The low mountain passes have provided valuable travel corridors between maritime and Interior cultures for centuries. The Chilkat and Chilkoot Tlingits resided in this area prior to European arrival. Europeans exploited these travel corridors during the Klondike Gold Rush of 1898 onward. Skagway and Dyea became important destinations for miners seeking their fortunes in the Yukon gold fields. The White Pass–Yukon Railroad was built from Skagway to Whitehorse at this time. Logging operations have extracted much of the low elevation timber in this subsection. Consequently, second-growth forests exist over most of the valleys and toeslopes. Travel and transportation continue to be important human uses of the area. Highways in Haines and Skagway provide motor access from Southeast Alaska to the Canadian Interior. Much of the area is in state and private ownership. The Haines State Forest and Resource Management Area, Chilkat State Park, and Klondike Gold Rush National Historic Park are located here.

Sitka National Historic Park

Sitka Sound Complex

The Outer Coast Wave-cut Terraces front this picturesque view of Sitka and the steep, angular mountains that comprise this subsection. Povorotni Point is in the foreground. The cruise ship on the right is in front of Mt. Verstovia.

These highlands encircling Sitka Sound include the mountains on northwest Baranof Island, Halleck, Krestof and Partofshikof Islands, and the northern third of Kruzof Island. This area was blanketed by 2 to 6 feet of ash about 9-12,000 years ago (Riehle et al. 1992). Over time, these volcanic deposits have washed downslope exposing the underlying Sitka graywacke, granite, and low-grade metamorphic rocks such as phyllites. Much of this area is considerably lower in elevation than surrounding subsections, particularly Halleck, Krestof and Partofshikof Islands. This subsection has no glaciers, although it does contain a few permanent snowfields on Baranof Island. Volcanic ash and cinders are the principal parent materials, covering over 50% of the subsection. Landslides are common on ash-coated surfaces, particularly in areas roaded during the 1960-70s. Hemlock-spruce and hemlock forests dominate shorelines and low

elevations. Forested wetlands of lodgepole pine and mixed conifers are relatively abundant compared to bordering subsections to the east. The alpine and coastal forest habitats support brown bear, Sitka black-tailed deer, mountain goat (introduced), marten (introduced), common shrew, Keen's mouse, and tundra vole.

Land-Human Interactions. This area has a rich and diverse cultural history. The Sitka Tlingits originally lived here using the abundant resources of the area. A concentration of Native villages occurred around Sitka Sound. In pursuit of valuable sea otter pelts, the Russians built a trading post near Sitka in the 1790s. A series of battles ensued with the Sitka Tlingits before the Russians established their American capital at Sitka in 1804. During the Russian occupation, most forests near saltwater were selectively logged around Sitka Sound and more distant shorelines. One of the oldest clearcuts on the West Coast occurs on Mount Verstovia near Sitka. Today, the U.S. Forest Service manages much of the area for mostly natural settings. About one-quarter of this subsection is designated for development. Less than 10 percent of the land is privately owned. While the paper mill was in operation in Sitka, about 8,400 acres have been harvested mostly in valley bottoms and riparian areas, representing about 9 percent of the productive forest. This harvesting occurred from the 1950s–70s.

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